

## COPPER ALLOY AND METHOD FOR ITS MANUFACTURE

The invention relates to a copper alloy and a method for its manufacture which alloy has a high recrystallization temperature as well as good electrical and thermal conductivity. The copper alloy of the invention is advantageously used as cooling fins in brazed heat exchangers for instance in automobiles.

A new joining technology for brazing using copper and brass for automotive heat exchangers has been developed in recent years. In brazing, the metallic parts of a heat exchanger are joined by a molten metal, i.e. a filler metal, the melting temperature whereof is lower than that of the parts to be joined. The brazing is similar to the soldering. However, in brazing the working temperature is more than 450 °C. The working temperature of the brazing filler metal depends on the chemical composition of the filler material. In the US patent 5,378,294 there is described a brazing filler alloy which is based on low-nickel copper alloys having a low melting temperature and being self-fluxing. The working temperature for these alloys is between 600 and 700 °C.

The mechanical properties of the metal used in a heat exchanger are reached through alloy additions and cold working. In the heat exchangers there are usually fins and tubes which are soldered or brazed together. A cold worked metal will start to soften, i.e. recrystallize when heated. Therefore, alloy additions are made to the fin material to increase the softening temperature. It is necessary that the fins of the heat exchangers retain as much as possible of their original hardness after joining. In the US patent 5,429,794 there are described copper-zinc alloys suitable for heat exchangers, particularly for radiators, because they can be brazed without losing too much strength.

When thinking of the conductivity of a heat exchanger material, the alloying of copper will decrease the electrical conductivity, as in the alloys of the US patent 5,429,794. Now it is surprisingly noticed that there is a copper alloy for heat

exchangers which alloy has good electrical conductivity. Therefore, the object of the present invention is to eliminate some of the drawbacks of the prior art and to achieve a better alloy and a method for manufacturing that alloy used in heat exchangers which alloy is low-alloyed copper and is easy to braze, so that the alloy has high recrystallization temperature as well as has good electrical conductivity. The essential novel features of the invention are apparent from the appended claims.

According to the invention phosphorus deoxidized copper is alloyed by chromium in which alloy the chromium content is between 0.1 and 0.3 % by weight advantageously between 0.15 and 0.25 % by weight. Preferably the alloy consists essentially of copper and chromium, any other materials present being incidental constituents and impurities.

The alloy of the invention has a high recrystallization temperature, eg. at least 625 °C which is convenient for brazing in order to prevent the softening. This is because brazing is normally done at the temperature of more than 600 °C. The alloy is advantageously manufactured through continuous casting and cold working so that the electrical conductivity after brazing is at least 90 % IACS (International Annealed Copper Standard).

The alloy of the invention is manufactured by a method which advantageously includes the following steps: casting, cold working, annealing and another cold working before brazing. The casting step can advantageously be carried out as a continuous strip casting. At least one of the cold working steps is preferably carried out by rolling. When carrying out the annealing step it is advantageously with a strand annealing, i.e. a rapid annealing in which the annealing time is between 0 to 30 seconds eg. 0.01 to 30 seconds preferably 1 to 10 seconds and the annealing temperature is at the range between 700 and 900 °C, preferably 700 to 800 °C.

Using the manufacturing method of the invention, the electrical conductivity of the alloy increases during every step. This is believed to be because the precipitation of chromium takes place in all steps. The precipitates have a fine distribution and good stability. During the brazing step essentially all chromium of the alloy is  
5 precipitated and the alloy then has good electrical conductivity. Because the copper alloy of the invention has good electrical conductivity also, the thermal conductivity is good and the alloy is suitable for heat exchangers.

The invention is described in details in the following example and in the following  
10 drawing where the effect of the process steps on the electrical conductivity is illustrated.

#### Example

15 The alloy in accordance with the invention having 0,2 % by weight chromium, rest copper, was first cast using a continuous strip cast. After casting the electrical conductivity was measured and the value was 50 % IACS. The strip cast alloy was then cold rolled to the thickness of less than 0,1 mm and the value for the electrical conductivity was 50 % IACS. The rolled alloy was then annealed at the  
20 temperature of 750 °C for 5 seconds. After this annealing step the electrical conductivity had a value of 56 % IACS. The alloy was again cold rolled to the final dimension of 0.05 mm and the value of the electrical conductivity was 61 % IACS. The brazing was then done for the final product at the temperature of 625 °C. After brazing the value for the electrical conductivity was again measured and the  
25 value was 94 % IACS.

The yield strength of the fins made of the copper alloy of the invention after brazing was 250 MPa and the fins were not recrystallized. The above described variation of the electrical conductivity is illustrated in Fig. 1. In Fig. 1 there is also  
30 illustrated as a comparison the theoretical conductivity. The theoretical values are calculated from the equilibrium diagram for the copper-chromium system. The

curves show the influence of chromium in solid solution on electrical conductivity. The influence of cold deformation is taken from the relation between electrical conductivity for low-alloyed copper and reduction during cold deformation. The alloy manufactured by the method of the invention has 10 % IACS better conductivity after brazing than the theoretical conductivity.